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Study Suggests Math Teachers Scrap Balls and Slices

By KENNETH CHANG

One train leaves Station A at 6 p.m. traveling at 40 miles per hour toward Station B. A second train leaves Station B at 7 p.m. traveling on parallel tracks at 50 m.p.h. toward Station A. The stations are 400 miles apart. When do the trains pass each other?

Entranced, perhaps, by those infamous hypothetical trains, many educators in recent years have incorporated more and more examples from the real world to teach abstract concepts. The idea is that making math more relevant makes it easier to learn.

That idea may be wrong, if researchers at Ohio State University are correct. An experiment by the researchers suggests that it might be better to let the apples, oranges and locomotives stay in the real world and, in the classroom, to focus on abstract equations, in this case $40 (t + 1) = 400 - 50t$, where t is the travel time in hours of the second train. (The answer is below.)

“The motivation behind this research was to examine a very widespread belief about the teaching of mathematics, namely that teaching students multiple concrete examples will benefit learning,” said Jennifer A. Kaminski, a research scientist at the Center for Cognitive Science at Ohio State. “It was really just that, a belief.”

Dr. Kaminski and her colleagues Vladimir M. Sloutsky and Andrew F. Heckler did something relatively rare in education research: they performed a randomized, controlled experiment. Their results appear in Friday’s issue of the journal Science.

Though the experiment tested college students, the researchers suggested that their findings might also be true for math education in elementary through high school, the subject of decades of debates about the best teaching methods.

In the experiment, the college students learned a simple but unfamiliar mathematical system, essentially a set of rules. Some learned the system through purely abstract symbols, and others learned it through concrete examples like combining liquids in measuring cups and tennis balls in a container.

Then the students were tested on a different situation — what they were told was a children's game — that used the same math. "We told students you can use the knowledge you just acquired to figure out these rules of the game," Dr. Kaminski said.

The students who learned the math abstractly did well with figuring out the rules of the game. Those who had learned through examples using measuring cups or tennis balls performed little better than might be expected if they were simply guessing. Students who were presented the abstract symbols after the concrete examples did better than those who learned only through cups or balls, but not as well as those who learned only the abstract symbols.

The problem with the real-world examples, Dr. Kaminski said, was that they obscured the underlying math, and students were not able to transfer their knowledge to new problems.

"They tend to remember the superficial, the two trains passing in the night," Dr. Kaminski said. "It's really a problem of our attention getting pulled to superficial information."

The researchers said they had experimental evidence showing a similar effect with 11-year-old children. The findings run counter to what Dr. Kaminski said was a "pervasive assumption" among math educators that concrete examples help more children better understand math.

But if the Ohio State findings also apply to more basic math lessons, then teaching fractions with slices of pizza or statistics by pulling marbles out of a bag might prove counterproductive. "There are reasons to think it could affect everyone, including young learners," Dr. Kaminski said.

Dr. Kaminski said even the effectiveness of using blocks and other "manipulatives," which have become more pervasive in preschool and kindergarten, remained untested. It has not been shown that lessons in which children learn to count by using blocks translate to a better understanding of numbers than a more abstract approach would have achieved.

The Ohio State researchers have begun new experiments with elementary school students.

Other mathematicians called the findings interesting but warned against overgeneralizing. "One size can't fit all," said Douglas H. Clements, a professor of learning and instruction at the University of Buffalo. "That's not denying what these guys have found, whatsoever."

Some children need manipulatives to learn math basics, Dr. Clements said, but only as a starting point.

"It's a fascinating article," said David Bressoud, a professor of mathematics at Macalester

College in St. Paul and president-elect of the Mathematical Association of America. “In some respects, it’s not too surprising.”

As for the answer to the math problem at the top of this article, the two trains pass each other at 11 p.m. at the midway point between Stations A and B. Or, using the abstract approach, t = 4.

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